separate, the leaves gradually extend, forming with the axis a greater and greater angle, and some finish by turning themselves down towards the base of the branch.

It is under the last form that the plant accomplishes, in the most apparent manner, the movements to which we refer. These become more manifest when young branches grown in an aquarium assume, in consequence, a slender and weak aspect, and the leaves become almost capillary. Consequently the best manner of observing and measuring the oscillations consists in submerging a piece of the stem bearing an axillary bud, and fixing the fragment by means of a weight. The young branch then assumes a vertical position, and its movements soon make themselves apparent. It is then easy to see that the movement of flexion is produced first in the superior internodes, and that it is propagated thence in a diminishing degree from above downwards; while, on the contrary, the movement of erection commences with the inferior part terminating with the superior, which sometimes, shortly before quite recovering itself, forms with the axis a very acute angle.

The oscillations continue very apparent during several days; ordinarily they diminish at the end of a certain time. Their amplitude decreases, and the branch becomes motionless or apparently so. But after thus remaining stationary it may resume its former variations. There are, moreover, branches, especially those which are almost horizontal, which continue motionless.

Light does not appear to have any influence on these movements. At least the suppression, the diminution, the change of colour, or the direction of the luminous rays have not had any apparent influence on them. Although I have seen the leaves participate in the movements of the axis, the modifications they have undergone may well be mechanically produced by the inflexions of the axis itself.

As to the movement of torsion, I am not able to say anything precise for want of experiments sufficiently conclusive. The movement is nevertheless very apparent. It takes place sometimes in one direction, sometimes, and much more energetically in another. By means of an index made of a thin plate of mica or glass, supported by a small glass float sufficiently weighted, the whole resting on one of the whorls, and carefully turned round by means of a pin moving over a scale, I have measured angles of tension of 35 degrees in nine hours, 120 degrees in seven hours, 450 degrees in nine hours, &c. But having only lately commenced the research, I must abstain from co-ordinating the results.

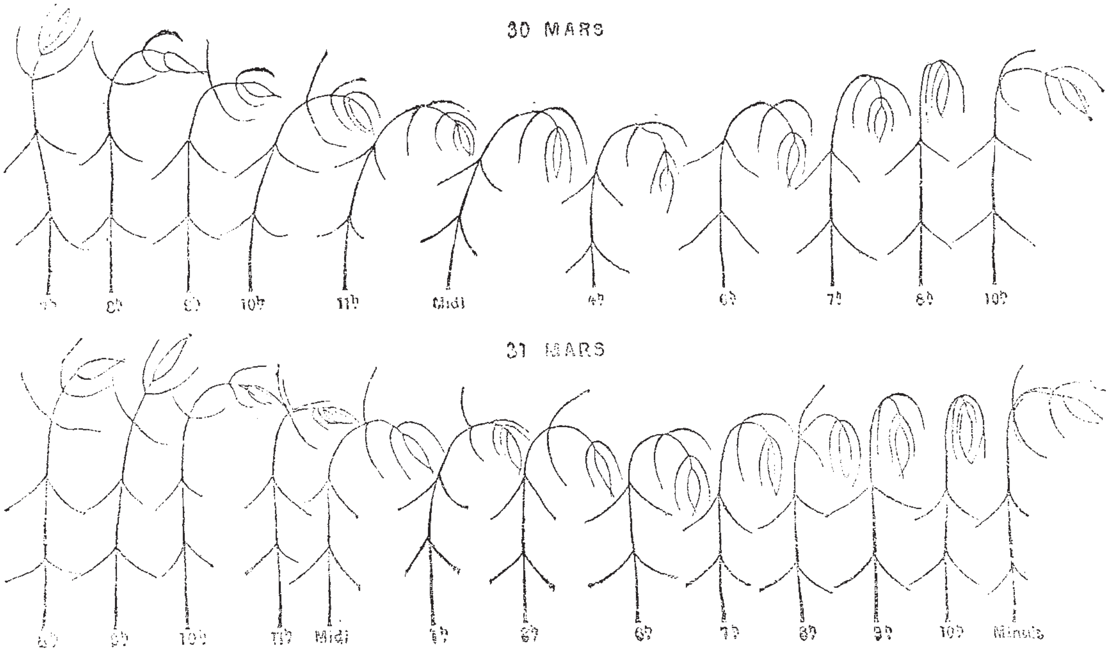

FIG. 1.—Various positions assumed by a branch of *Ceratophyllum demersum*.

Such are the general facts which I have to indicate, and in support of which I give an illustration of particular cases. The figure gives for a branch nineteen positions for March 30 and 31 and April 1. The very marked movements took place from north-east to south-west, and the entire evolution in twenty-six hours.

The priority of action of the superior internodes for the flexion, and that of the inferior internodes for the erection, is here very evident. The nutant attitude of the apex of the shoot, almost at the moment of complete erection, is also extremely striking.

To April 26 the movements continued, but they were then limited to the superior extremity of the branch. It appeared to shrink from the light, but as at the same time a branch in close proximity turned towards the light, the direction of displacement could not be so accounted for. I, nevertheless, during the following days (1) totally suppressed the light, (2) threw light upon the plant, by means of a mirror, in a direction opposite to that of the ordinary light, (3) placed a screen reaching almost to the middle of the plant, (4) placed in the path of the rays a red glass, intercepting as far as possible the other rays. The phenomena remained the same.

NOTES

THE Queen has conferred the honour of the Companionship of the Civil Division of the Order of the Bath on Prof. Frederick Augustus Abel, F.R.S., Chemist to the War Department and President of the Chemical Society, and on Major-General Charles Wright Younghusband, F.R.S., R.A., Superintendent of the Royal Gun Factories.

THE University of Cambridge proposes to confer the degree of LL.D. upon Mr. Charles Darwin.

Under the title "Challenger-Briefe" a collection of letters are now being published at Leipzig (Engelmann), which were written by the well-known zoologist, Dr. Rudolph von Willemoes-Suhm, of Munich, to his mother during the years 1872–5, when he was taking part in the *Challenger* Expedition, from which he was never to return. Prof. Kupffer has written a preface to these interesting documents.

We are glad to be able to state that the fears expressed in our paragraph a fortnight ago respecting the loss of Mr. Seebohm's collections in the wreck of the *Thames* were unfounded. Mr. Seebohm has reached England with a very large collection of birds' skins and eggs, made in Northern Russia during the past summer.

The following changes in the council of the London Mathematical Society are proposed to be made for the coming session: Prof. Clerk Maxwell, F.R.S., and Mr. Harry Hart to take the places of Prof. Clifford, F.R.S., and Rev. R. Harley, F.R.S., who retire. Prof. Maxwell to be a vice-president in the room of Mr. Spottiswoode, F.R.S., who becomes an ordinary member of the council.

M. Faye is to give an address on Thursday, at the quarterly meeting of the five academies; he has chosen for his subject "The non-existence of any lunar action on weather."

A special meeting of the Society of Telegraph Engineers will be held on Wednesday the 31st inst., under the Presidency of Prof. Abel, C.B., F.R.S., when a paper will be read by Prof. Graham Bell on the Telephone, and its working will be fully illustrated.

Dr. Janssen's observatory for physical astronomy is in full operation at Meudon, on the site of the old palace which was burnt during the Paris siege; the instruments are placed under a number of domes on the terrace. A credit will be asked from the new Legislative Assembly for repairing the ruined buildings. Dr. Janssen is preparing a memoir on the results of his numerous photographs.

Mr. E. Wilson has recently imported some live ants from Australia, and presented them to Sir John Lubbock. This is the first time that ants have been brought over alive from the Antipodes. They are said to be stingless, and as there is no queen, there is no fear that the Australian ants should take the place of the Colorado beetle!

A number of Esquimaux are expected daily at the Jardin d'Acclimatation, Paris, with their dogs, sledges, &c. They are to stay at the Gardens during winter, camping out of doors.

M. Marche, one of the Ogové explorers, was present at the last meeting of the Paris Geographical Society. He expressed the decided opinion that, considering all the circumstances connected with Stanley's discovery, the Ogové is merely a branch of the Congo. He met some natives on his journey who said they came from a large river where white men are to be found, which river cannot possibly be other than the Congo. The course of the stream gave indication of a south-easterly bend which supports such a hypothesis.

The Geographical Society of Paris purchased a piece of ground for building its hotel, some time ago, and the Municipal Council of Paris has diminished by about 2,000*l.* the purchase-money which had been agreed upon. That sum is about one-fourth of the total price.

At the Huddersfield Mechanics' Institution, on Tuesday, Mr. Forster again insisted on some of the ideas so forcibly brought out by him recently at Bradford. The gist of his address was that it will be impossible to stop at the three R's in elementary teaching; that, as in Germany, Switzerland, and America, elementary schools should be supported entirely from the taxes, and that the education should be such that tax-payers of any class might send their children to these schools in the confidence that they would get a complete and thorough education; whether they did so or not would be their own affair.

Lord Hartington laid, on Wednesday last week, the foundation-stone of a public hall to be erected in memory of George Stephenson, at Chesterfield. The hall will cost 13,000*l.*, and is to be used for scientific and educational purposes.

We would call the attention of our readers to a scheme for a Channel Islands' Museum and Institute of Pisciculture Society, the objects of which will be found described in our advertising pages. The scheme seems to us to deserve encouragement.

At Leipzig a "German Society for Mental Work" has been founded. Its object is the promotion of literature, art, and science, and of mental culture generally, in all German lands, on the basis of a contest against materialism, inasmuch as materialism is looked upon as a hindrance to the ideal aspirations and triumphs of the nation. The principal seat of the Society is to be at Leipzig, but the yearly meetings are to be held in various cities. The president for the current year is a Dr. Beyer, and the organ of the Society is to be the periodical *Literarische Korrespondenz.* Two deputies for South Germany have been elected: Herren Herm. Lingg (Munich), and Schmidt-Weissenfels (Stuttgart).

This year's meeting of the German Society of Viticulture was held on September 26 at Freiburg, in the Breisgau, and lasted until September 28. The principal subject discussed was the best method of destroying phylloxera.

The Botanical Society "Flora" of Dresden will, next year, in celebration of its fifty years' jubilee, hold four great exhibitions of plants. The respective dates are fixed as follows: March 21–25, May 16–20, June 25–29, and October 3–7. The exhibitions will be under the superintendence of Dr. Krause, the director of the Royal Gardens at Dresden.

Karl Russ, the well-known ornithologist and editor of the *Isis* and the *Gefiederte Welt*, has recently published a pamphlet on carrier-pigeons, which is extremely interesting. The Imperial Post and Telegraph Offices of the German Empire have, by the recommendation of the German Postmaster-General, Dr. Stephan, purchased large numbers of the little book, and a French translation is now in progress.

The "Dismal Swamp," so well known in connection with American slave-stories, the *New York Tribune* informs us, is said to be an entire misnomer. There is nothing dismal about it except its general solitude. It is described by recent visitors as a capital resort for sportsmen, game being abundant, and fish ready to rise to the fly. The most curious features of the swamp are the sweetness and wholesome character of the water, and the entire freedom of its few inhabitants from malarious diseases. This purity is ascribed to the influence of the juniper tree, which certainly colours if it does not improve the water, and possibly contributes an antiseptic property to the air.

Several bolides have been observed in France, one on October 14, at half-past 6 P.M., from Vincennes (near Paris), Havre, and Clermont-Ferrand, appearing in the vicinity of the Great Bear; another on October 16, at 8 P.M., at Chambery, travelling from east to north-west.

The annual meeting of the Yorkshire Naturalists' Union was held on October 6 at Wakefield. The annual report showed that the past year had been one of unusual success and steady progress. Six meetings had been held—at Pontefract, Wetherby, Nostell Priory, Shipley Glen, Goole, and Copley, and the attendance had uniformly been good. The sections which had been established had quite justified by success the experiment of their formation. The number of societies in union had increased from twenty-one to twenty-five, and of members from 1,050 to 1,300. The change of name having been mentioned, the proproposed issue of Transactions was spoken of. In response to the council's appeal for funds, a liberal, though of course not as yet sufficient, response had been made. There are at present about 105 subscribers to the funds, which, after defraying the expenses of the meetings, will be devoted to the publication of Natural History Transactions for the county. The financial statement showed a balance available for purposes of publication of over 20*l*. Mr. Henry Clifton Sorby, F.R.S., of Sheffield, was unanimously elected president.

THE Committee of the Chester Society o Natural Science announces that in connection with the Gilchrist Educational Trust, six Popular Science Lectures will be given in the Town Hall, Chester, on successive Tuesday evenings, commencing Tuesday, November 6, by Prof. W. C. Williamson, F.R.S., Prof. P. Martin Duncan, M.D., F.R.S., and Dr. William B. Carpenter, C.B., F.R.S. The admission to each lecture is only one penny. The Chester Society has founded a Kingsley Memorial, which has taken the form of a number of prizes, details concerning which will be found in our advertising columns.

THE following is the title of the essay to which the Howard Medal of the Statistical Society will be awarded in November, 1878, the essays to be sent in on or before June 30, 1878, "The Effects of Health and Disease on Military and Naval Operations." The council have decided to grant the sum of 20*l*. to the writer who may gain the "Howard Medal" in November, 1878.

M. DE FONVIELLE sends us an account of a balloon ascent he made on the 18th instant in the *Hydrogene*. The departure took place from the Champ de Mars at half-past three P.M. The balloon at first was pushed by a gentle north-easterly wind blowing in the direction of the valley of the Seine to an altitude of 600 metres, when it met with another aërial current coming from north-west. The air was quite moist. The rays of the disappearing sun covered the ground with a strong red colour, and M. de Fonvielle suggests that the planet Mars takes its reddish shade owing to the large quantities of vapour disseminated in its atmosphere. When the *Hydrogene* was passing from the inferior current to the superior it received a sensible shock and vibrated like a pendulum for some time. From 1,200 metres to 1,600 he found a wind blowing from the north-east like the first met after starting. The air was cold and dry. The temperature, when ascending, was 13° Cent. in the shade and at 1,600 meters he found 3° Cent. under 0. When landing at a quarter-past six the thermometer gave 10° Cent. on the ground at Bonelle, about forty kilometers from the Champ de Mars. During about twenty minutes, having descended in the vicinity of land not above 300 metres, the balloon met a south-westerly wind which was prevailing in the valleys of Bievre. That current of air was obviously enough a modification of the principal wind in consequence of the hilly character of the district. Such local winds observed by meteorologists can lead to no practical conclusions at all. If we consult the readings taken at the stations of the International Service on October 18 at six P.M., we find almost no two stations having the same wind in the Parisian district. The only wind worthy of note was that shown by the direction of the clouds, and of which no account was taken. M. de Fonvielle states he never met in his many aërial journeys with circumstances so strongly in favour of the introduction of cloud observations in weather prognostications. The principles advocated by Buys Ballot, and practised by Norwegian observers, received a strong confirmation.

ON the map of Major W. F. Raynolds, embracing that portion of the Missouri River country traversed by himself in 1859 and 1860, there was first recorded the peculiar hydrographical feature known as the "Two-Ocean Water." Its position is there indicated roughly by means of dotted lines, according to the account given by Bridger, the guide of the party. In the report of the expedition Raynolds remarks that "having seen this phenomeon on a small scale in the highlands of Maine, where rivulet discharges a portion of its waters into the Atlantic and the remainder into the St. Lawrence, I am prepared to concede that Bridger's 'Two-Ocean River' *may* be a verity." Dr. Hayden, after a careful reconnaissance of the region, reported that such a phenomenon was at least doubtful, at the same time suggesting that the "low ridge in the great water divide of the continent has doubtless given rise to the story of the Two-Ocean River, and such a stream has found its way to most of our printed maps. The expedition of Capt. W. A. Jones, in 1873, ascended the valley of the Upper Yellow-stone for twenty-five or thirty miles, the trail of the party left the marshy bottom-lands to traverse the drier portion about fifty feet above the stream upon the right bank. The river at this point was then (early in September) rather sluggish, the slope being somewhat gradual. Presently they crossed a small, but rapid rivulet, coursing down the mountain side, and falling abruptly into the valley just beneath them. Beyond them the view was unobstructed, but the stream appeared to ascend the slope towards them, until they observed that the rivulet had divided in the plain below, one portion gliding silently into the river behind them, to find its way at last into the Gulf of Mexico, while the other branch had descended in front to join the westward flowing waters of the Columbia, *via* Snake River, finally reaching the Pacific Ocean. The true position of this remarkable feature of physical geography is clearly shown on the map which illustrates the report of Capt. Jones ("Report upon the Reconnaissance of N.W. Wyoming made in the summer of 1873, by Wm. A. Jones, Captain of Engineers. Washington: Government Printing Office, 1874"). The mountain stream now bears the name proposed by Raynolds—the "Two Ocean Creek"—and its two branches are named respectively, Atlantic and Pacific creeks. Thus is verified another of the stories of that faithful guide and hunter—James Bridger—one of the most worthy of Rocky Mountain pioneers.

THE Eleventh Annual Report of the Warden of the Standards has been issued. The office of Warden of the Standards, on the retirement of the late Warden, Mr. Chisholm, was associated with that of the Permanent Secretary of the Board of Trade, so that the Report is signed by "T. H. Farrer," as Warden of the Standards. The practical duties of the department are discharged by Mr. H. J. Chaney. Among the subjects referred to in the Report is the rude and antiquated method of teaching weights and measures in our schools, which has been referred to in previous papers of the department. It would appear, from present arithmetic books that the student may still be taught the particulars of weights or measures which can be of no possible use to him in after-life. Another interesting point referred to is the merits of "short-arm" and "long-arm" balances. To meet the requirements of modern science a balance is needed by which the weights of bodies may be determined most accurately and quickly. Prof. Mendeléef, of St. Petersburg, and Herr Bunge, Mechanicus, Hamburg, have shown that it is possible to weigh quickly and accurately by the use of a balance whose beam has much shorter arms than those now in general use. A practical test of the relative merits of a beam with long arms and of one with short arms has been made in the department. By this test, as well as from the mathematical consideration of the question, it has been ascertained that whilst the probable error of a weighing made with the short-arm balance is slightly greater than the probable error of a weighing made with the long-arm balance, yet a weighing by the long-arm balance occupies twice as much time as one made with the short-arm balance. Consequently great economy of time is obtained by the use of a short-arm balance. Prof. Barff's process for preventing the corrosion of iron appeared to the department to be likely to prevent the oxidation of Standard weights made of iron. Prof. Barff has undertaken to submit some specimens of iron weights to this process, and it is intended to place these weights in the hands of some local inspector of weights and measures so that it may be ascertained whether iron Standard weights thus protected could safely be used in place of the expensive bronze or brass Standard weights at present used. The Report refers to several other points connected with the working of the department, one of importance to the general public being its operations in connection with the testing of gas-meters.

Mr. A. Ringwood, of Adelaide, South Australia, publishes a plan by which one observer may measure the height of the clouds. The observer is to note the altitude and azimuth of the cloud, the azimuth of the cloud's shadow, and the spot in the surrounding country where the shadow falls; from this last observation by means of a map he can find the distance of the shadow from him. From these elements, together with the altitude and azimuth of the sun, a variety of expressions for the height of the cloud can be deduced. The method is equivalent to taking observations at each end of a base whose length is the distance of the shadow from the observer, the observer at the shadow end of the base being the sun. The difficulty of recognising the shadows of individual clouds and the comparatively short time in each day during which it would be possible to do so, joined with the fact that the higher clouds, such as cirrus and cirrocumulus, hardly ever cast defined shadows, must prevent the method from becoming generally useful; but still there is this to be said for it, that if in an observation the base, *i.e.*, the distance of the cloud's shadow from the observer, is long, a good measure of the height of the cloud may be got with comparatively rough observations of the other elements.

The singing of mice is a phenomenon which was recently affirmed by Dr. Berdier in a letter to *La Nature*. A distinguished herpetologist, M. Lataste, suggested that he may have made confusion with the singing of a raniform batrachian, the *Bombinator igneus*, but Dr. Berdier said there was no marshy ground near the room in which he had heard it, and he stuck to his assertion. His observation has been confirmed at a recent meeting of the French Société d'Acclimatation, by M. Brierre, who stated that he, with several others, had heard mice sing at Saint-Michel-sur-l'Heron (in Vendée), in 1851–1853. The singing (which was at first attributed to reptiles) came from an old cupboard bought in a market-place, and concealing mice. It was about sunset that the sounds generally commenced. M. Brierre soaped the joints and the wood so that he might open the cupboard suddenly without noise. He did the latter one evening soon after the sounds had commenced, and succeeded in observing, for about a minute, the movements of the throat of a mouse, which emitted a song like that of a wren, the snout being elongated and held up in the air, as a dog does when he howls. He seized the animal with his hand and called others to see it, but it got off. The singing was resumed the same night and those following. M. Brierre is unable to attribute the singing of the mice (as Dr. Berdier does) to imitation of that of canaries, for he had no birds in the house, nor had the previous proprietor of the cupboard any.

In describing some recent falls of meteoric stones in America, Mr. Lawrence Smith has pointed out (*Comptes Rendus*) that in the last eighteen years there have been, in the United States, twelve falls of meteorites which have been collected; and he notes the remarkable fact that eight of the meteorites, representing more than 1,000 kilogrammes of matter, have fallen in the region of the Western Prairies, and on a surface which does not exceed one-eighth of the extent of the United States. This cannot evidently be attributed to there being a dense population and numerous observers (a consideration sometimes urged). Still more striking is the circumstance that in the last sixty years there have been twenty falls of meteorites observed in the United States, of which ten, or the half, have fallen in this same region; and, moreover, these falls have brought about 1,200 kilogrammes of mineral substance, a quantity twenty times greater than that of the ten other falls recorded as having occurred outside of this region.

It has long been known that the photographic image of a luminous object is dilated at the expense of the dark parts or the field itself. This has been merely attributed to a gradual advance of the chemical action (without further attempt at explanation). The phenomenon has recently been studied by M. Angot (*Journal de Physique*). He finds that the dimension of the images increases with the intensity of the light, with the duration of exposure, with the sensibility of the plate, with diminution of the aperture of the objective, and that it is greater when the plate has not previously been impressed by diffuse light than when it has. M. Angot discards the hypothesis of a mysterious advance of chemical actions, and shows how the phenomena are accounted for by the ordinary theories of optics. This variation of the diameter of images is inevitable in practice; to render it very small the operator should satisfy himself that the objective used is aplanetic, *i.e.*, free, as far as possible, from aberrations of sphericity and refrangibility. He has only then to take account of variations due to diffraction, which may be attenuated by using objectives of large aperture. It is by using an objective without sensible aberration and of fifteen inches aperture that Mr. Rutherford has succeeded in obtaining his magnificent photographs of the moon.

Some interesting experiments on the photo-electricity of fluorspar have recently been described by M. Hankel to the Saxon Academy of Sciences. His attention was drawn to the phenomena in studying the thermo-electric properties of crystals. The new effects were found much more intense than those got by heating the crystal, or by friction of its surface with a brush; moreover, they were of contrary sign, and so must be attributed to an action proper to light. The principal results of experiment are these: The centre of a crystalline face presents, after exposure of about an hour to sunlight, a strong negative tension, while the tension towards the sides is much less, and even most frequently positive. An exposure of the crystal to the temperature of 95° for several hours produces, during cooling, the smallest positive tensions at all points of the crystal. Experiments made by filtering light through coloured glasses, a layer of water, a solution of alum or of sulphate of quinine, showed that the chemical rays are much the most active. Lastly, a too strong concentration of light on the crystalline face removes all sensibility to the ulterior action of light. To give an idea of the degree of tension observed in such experiments, M. Hankel states that a brass plate 95 mm. in diameter, connected with a zinc element, copper, and uninsulated water, gave a deflection (in an electrometer composed of a gold leaf hung from an insulated brass rod between two insulated plates of brass) of 1°·2 on approaching the centre point as nearly as possible, and about 0°·6 on approaching the edge. The deflections obtained by exposition to light reached 21°, and even 26° in the centre of surface of a crystal electrified by light.

As supplemental to the article on the blue gum-tree, at p. 443 of Nature, vol. xvi., the following notes from a report on the culture of *Eucalyptus* in Algeria by Consul-General Playfair will, no doubt, be interesting. With regard to rapidity of growth, it seems that the first trees ever planted in Algeria were sown in 1862, and upon being measured in 1874, that is at twelve years of age, gave a circumference at one metre from the ground of 1·52 metres, another of eleven years growth gave 1·42, and another, planted in fresh alluvial soil, nine years of age, gave 1·57 metres—about six inches more, Col. Playfair says, than he could embrace with both arms. To the question of the sanitary effects of *Eucalyptus* a good deal of attention has been directed. An inquiry was instituted by the Society of Physical and Natural Sciences at Algiers under the presidency of Dr. Bertherand, and the result was that from thirty localities reports were received, all of which speak favourably of the *Eucalyptus* as a fever preventive. On the banks of Lake Fetzara, near Bône, 60,000 young trees of *Eucalyptus globulus* were planted in 1869. At the present time they have attained a height of from 7 to 8 metres each, and have, it is said produced a very marked effect on the locality. Such was the feverish condition of this district on the annual fall of the water and the denudation of its banks that the director of the Jardin d'Essai, who went to examine the condition of the plants, was immediately seized with a violent fever which lasted twenty days. This gentleman, however, now reports that the miasmatic influences which affected him so strongly then have disappeared, and the mosquitoes which rendered the place uninhabitable have disappeared with them. At the great iron mines of Mokta et Hadid it was formerly impossible for the workmen to remain there during the summer; those who attempted to do so died, and the Company was obliged to take the labourers to the mines by train every morning, and to carry them back to Bône at night, a distance of 33 kilometres each way. From 1868 to 1870 the Company planted more than 100,000 *Eucalyptus* trees, and now the workmen are able to live all the year through on the scene of their labour. Consul Playfair advances the following reasons as accounting for the causes of the improvement in climate from planting *Eucalyptus* trees:—"In some places," he says," the trees destroyed miasma by utilising the moisture of the soil in which they were planted, and thus draining marshes; the emanations from their leaves also may have produced a salutary effect. They contain a large quantity of essential oil very similar to turpentine, which they emit in great quantities, especially when stirred by the wind, and this acts, it is supposed, as a febrifuge." We are further told that considerable numbers of *Eucalyptus* have been planted all along the railway from Algiers to Oran. Where this line passes through the Metidja the trees have grown most successfully, but in the Chelif they have proved almost an entire failure. This, however, may have been due to their receiving no attention whatever after being planted.

We have received reprints of two papers by Dr. C. Le Neve Foster, one "On Some Tin-Lodes in the St. Agnes District," and the other "On a Deposit of Tin at Park of Mines."

We have received an interesting little publication, by Mr. Edwin Lees, F.L.S., reprinted from the *Transactions* of the Malvern Naturalists' Field Club, on "The Forest and Chase of Malvern, its Ancient and Present State," with notices and illustrations of the most remarkable old trees remaining within its confines.

The additions to the Zoological Society's Gardens during the past week include a Bonnet Monkey (*Macacus radiatus*) from India, presented by Mr. Richard Turner; an Azara's Fox (*Canis azaræ*), two Brazilian Cariamas (*Cariama cristata*), a crested Screamer (*Chauna chavaria*) from the Argentine Republic, two Crab-eating Raccoons (*Procyon cancrivorus*) from South Brazil, a Yarrell's Curassow (*Crax carunculata*), a Sclater's Curassow (*Crax sclateri*), a Globulose Curassow (*Crax globulosa*), a Garden's Night Heron (*Nycticorax gardeni*) from Brazil, four Silky Cow Birds (*Molothrus bonariensis*), a Banded Cotinga (*Cotinga cincta*), a Yellow-footed Thrush (*Turdus flavipes*) from Bahia, deposited; an Ostrich (*Struthio camelus*) from Africa, received in exchange.

THE LIMITS OF NATURAL KNOWLEDGE[1]

II.

Having considered the capacity of the subject and the accessibility of the object, we must now turn our attention to the copula, *i.e.*, the demands which we make of knowledge.

As all conceptions which we form of nature are exclusively the results of sensual perception, our knowledge cannot go further than to compare the phenomena we have observed, and judge them with reference to one another. If any phenomenon of a special nature occurred only once, if, for instance, we were the only existing organisms our insight would be extremely limited, because all our knowledge of the human organism we have essentially obtained from its connection with all other organic beings. The comparison of many phenomena gives us a unit or a standard by which we can measure and determine each single one. We therefore obtain just as many measures as there are properties in nature which we can perceive by our senses or which can be inferred from sensual perceptions by our judgment. As these measures are deduced from finite facts they have only a relative value, and our knowledge remains finite for the same reason.

We therefore understand a phenomenon, we know its value with regard to other phenomena if we can *measure*, *count*, or *weigh* it. We have a clear idea of the size of the lowest fungus, of which we must place some 2,000,000 or 3,000,000 individuals side by side to complete the length of a metre, of the size of an elephant, of the earth, of our solar system, the radius of which is somewhere about 3,000,000,000 miles. We have a clear idea of the time in which a ray of light carries to our eye the writing of a book which we read, and which is about the $\frac{1}{800000000}$th part of a second—of the life-time of the lowest fungus which in a plant-box or in the human body is replaced by a new generation after only twenty minutes—of the life-time of an oak which may be several thousand years, and of the 500,000,000 years which have passed since the generation of organisms upon our earth.

Natural bodies are composed of parts; the value of their internal structure, of their organisation, is exactly determined by the quantity, nature, and arrangement of these parts. They therefore give us the measure by which we judge the compound whole, and with which we measure its organisation as it were. The morphological or descriptive natural sciences by these measurements obtain their scientific data. Chemistry, which at the present time is still an eminently morphological science and which investigates the formation of compounds from elementary atoms, and mineralogy, which presupposes the uniform arrangement of molecules, have arrived at a state of great perfection. The common measure for organisms is the cell, and further on the organ; the common measure for the systematic unities of organic nature (for varieties, species, genera) we find in individuals and generations.

We are enabled not only to compare the different objects and measure them by one another, but in as far as it changes, we may also compare a system, a unit (*einheitliche*) group of things of similar nature, with itself and measure it by itself. The knowledge of the change is complete if the later stage is proved to be the necessary consequence of the earlier one, or the latter to be the necessary predecessor of the later one, if one can be constructed from the other, if therefore both stages can be brought into the relation of cause and effect to one another.

In the elementary domains of the material this causal relation is the mechanical necessity, which for two successive stages demands the equal sum of motion in a certain direction (or living force) and of potential energy. Among the sciences which apply here astronomy ranks first; next in efficiency are several physical sciences, particularly the mechanical theories of heat and optics. Physiology, or the physics of the organic world, tries to penetrate into a far more difficult and more complicated domain, by following the footmarks of her older sister.

In the higher domains of the material we cannot for our causal knowledge uphold the demand for this mechanical necessity. Indeed this is perhaps impossible in the case of all structure.

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[1] Address delivered at the Munich meeting of the German Association, by Prof. C. von Nägeli, of Munich. (The author, in a note to the German original, remarks that this lecture had to replace another in the programme, which had been promised by Prof. Tschermak, of Vienna. At the eleventh hour Prof. Tschermak announced his inability to attend the Munich meeting, and the author was requested by the secretaries to fill the gap thus occasioned. The address therefore, the author states, bears the stamp of its hasty origin, as it was written during a journey in the Alps, when there was neither sufficient leisure nor opportunity for careful and elaborate work.) Continued from p. 535.